

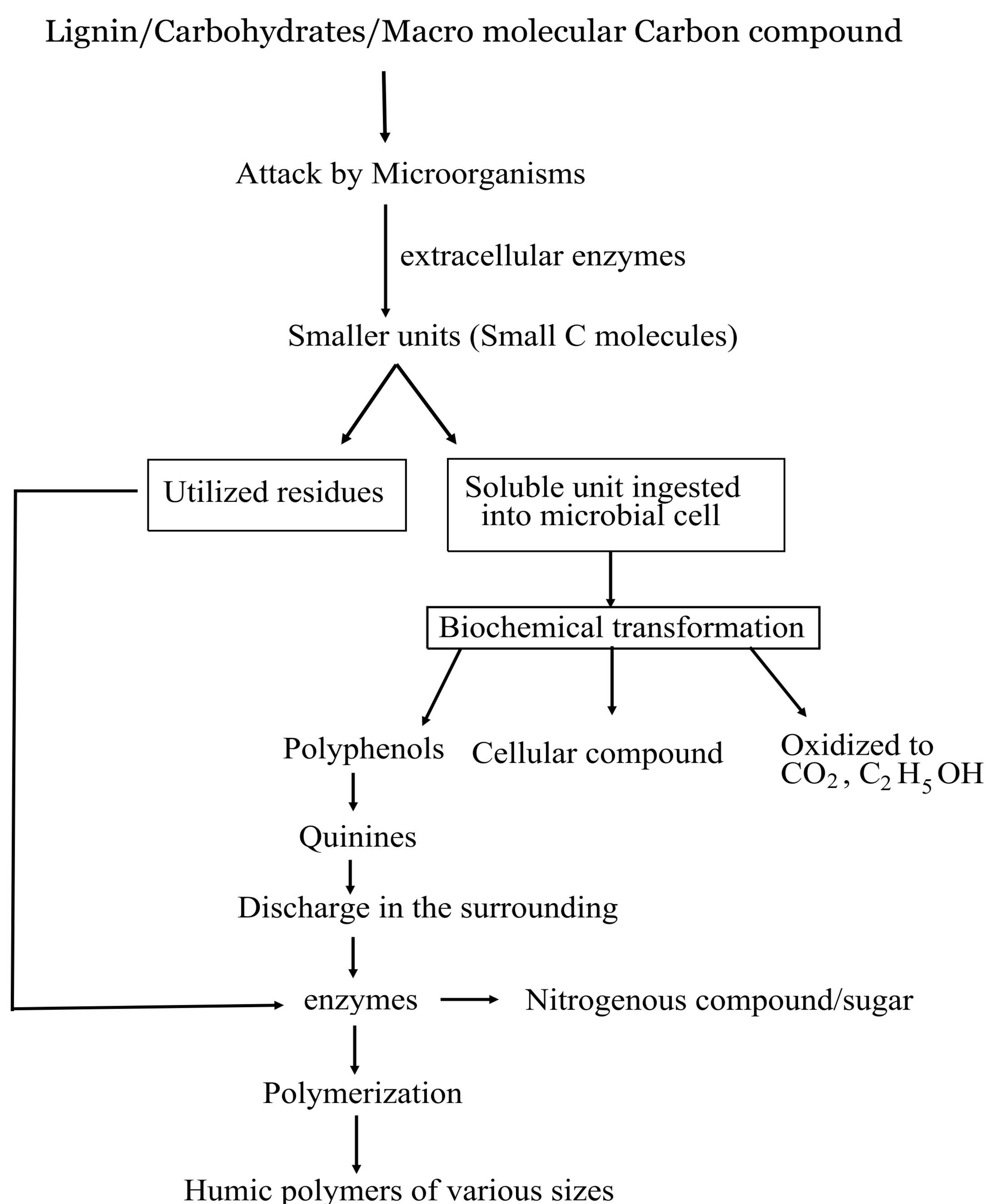
Organic Manure and Fertilizer

Humus formation Process

Plant residues contain mainly lignin, carbohydrates and protein. All of which are very high molecular weight, large size compound and are also chemically bound to one another. Microorganisms produce extra cellular enzyme which break down this macro molecules to smaller units. The Microorganisms are as who, apart of it is Oxidized to CO_2 and the rest is exuded in the form of different waste product (phenols/quinines) through by the transformation.

Polyphenols of the quinines appear to be common molecular waste which is find little use as a food (energy) sources by Microorganisms. Such compound therefore, accumulating soil. Phenol polymerization takes place under the influence of certain enzyme (phenol exuded) by Microorganisms. Phenols may also complementize with nitrogenous compound (amino acid), sugar and other degradation products in soil.

As a polymerization proceeds, the compound become dark brown or black and gets precipitated and huming polymers of various sizes are form.



Functions of Humus

1. Effective humus and stable humus are further sources of nutrients to microbes, the former provides a readily available supply, and the latter acts as a longer-term storage reservoir.
2. Humus is a colloidal substance and increases the soil's cation exchange capacity. From 20 to 70% of the exchange capacity of the soil is owing to colloidal humic substances.
3. Humus can hold the equivalent of 80–90% of its weight in moisture and therefore increases the soil's capacity to withstand drought conditions.
4. The dark color of humus (usually black or dark brown) helps to warm up cold soils in the spring.
5. Humus has a profound effect on the structure of soils. The deterioration of structure that accompanies intensive tillage is usually less severe in soils adequately supplied with humus.
6. Humus definitely increases the ability of the soil to resist erosion. It enables the soil to hold more water.
7. Humus serves as a source of energy for both macro and microorganisms. The numbers of bacteria, actinomycetes and fungi in the soil are related in a general way to humus content; faunal organisms are similarly affected.
8. The biochemical structure of humus enables it to moderate or buffer excessive acid or alkaline soil conditions.
9. Organic substances in soil have a direct physiological effect on plant growth. Some compounds such as phenolic acids have phototoxic properties; others such as the auxin, enhance the growth of higher plants.
10. Humus modifies the normal process of rock weathering by increasing the rate of dissolution of rock material. The productivity of present-day soils is intimately related to the effect that humus has on profile development.

Bio-fertilizer

Bio-fertilizer comes from alive particles or alive materials. The term 'Bio-fertilizer' or more appropriately microbial inoculant can be defined as the preparations containing live and latent cells of efficient strains of nitrogen fixing, phosphate solubilizing or cellulolytic microorganisms used for application to soil, seed or composting areas with the objectives of increasing number of such microorganism and accelerating certain microbial processes to augment the extent of the availability of nutrients in a form which can be easily assimilated by plants.

Or, In large sense, the term may be used to include all organic resources (manure) for plant growth which are rendered in an available form for plant adsorption through microorganism or plant association or interaction.

The fertilizer used to improve the fertility of the land using biological wastage, hence the term biofertilizer and biological wastage not containing any chemicals which are detrimental to the living soil. They are extremely beneficial in reaching the soil with those microorganisms which produce organic nutrients for the soil and help compact diseases. The farm product does not contain traces of hazardous and poisonous materials.

Thus those products are accepted across the world as organic ones. hence for organic farming the use of biofertilizers is mandatory.

Types of Bio-fertilizers

The following types of biofertilizers have been considered so far-

- Rhizobium inoculant.
- Azotobacter inoculant.
- Azospirillum inoculant.
- Cyanobacterial inoculant.
- Azolla.
- Phosphate solubilizing microorganisms.
- Mycorrhizal fungi.
- Inoculants for nodulated leguminous trees.
- Frankia inoculant for some non-leguminous trees.

Importance/ Uses of Biofertilizers

1. Biofertilizers increases the nitrogen content of soil.
2. Biofertilizers prepared with phosphate solubilizing microorganisms increases the phosphorus availability in soil.
3. Bio-fertilizer are environmentally friendly. They can be used for the protection of environment.
4. Some biofertilizer such as Azolla and BGA compact the toxic effect arising from fertilizer and pesticides.
5. It increase the yield of crop.
6. Biofertilizer improve the fertility status of soil, improve soil health and increases the yield of crop.
7. It improve physical, chemical and biological properties of soil responsible for enhanced

fertility and productivity.

8. They help proliferation and survival of other beneficial microorganism.
9. They are naturally preparation having self generating nutrient supply capacity.
10. Some biofertilizer protect the crops from various soil borne disease.
11. Some fertilizer particularly BGA can control the salinity of soil.
12. Biofertilizer acts as buffer against rapid change in soil pH.
13. In addition to N biofertilizer increase the amount of available P, Zn & Fe in soil.
14. Biofertilizer prepared with phosphate solubilizing microorganism increases the phosphorus availability in soil.
15. They are very cheap.

Difference between Manures and Fertilizer

Manures	Fertilizer
1. Naturally produced.	1. Synthetically produced.
2. Have no definite chemical formula or composition.	2. Have definite chemical formula or composition.
3. Nutrient content low.	3. Nutrient content high.
4. Supplies nutrient indirectly.	4. Supplies nutrient directly.
5. More than one nutrient is present.	5. Generally one or two nutrient is present.
6. Action is low.	6. Action is rapid.
7. Improves soil condition.	7. May deteriorate soil structure and affect soil pH.
8. Low cost of production.	8. High cost of production.
9. Can be stored for long time.	9. Can not be stored for long time.
10. It is generally organic in nature.	10. It is generally inorganic in nature.

Difference between Organic matter and humus

Organic matter	Humus
1. It is relatively less complex.	1. It is relatively more complex.
2. Fresh and partially decomposed organic matter.	2. Highly decomposed organic matter.
3. No new products are formed.	3. New products are formed.
4. It is unstable.	4. It is fairly stable.

5. C:N ratio is high.	5. C:N ratio is low.
6. Carbohydrate content is high.	6. Carbohydrate content is low.
7. Protein and lignin content is less.	7. Protein and lignin content is more.
8. Organic matter goes further decomposition.	8. Humus does not go any further decomposition.
9. Original tissues can be recognized.	9. Original tissues can not be recognized.
10. It is less darken in colour.	10. It is more darken in colour.
11. No colloidal in nature.	11. Colloidal in nature.

Role of Organic matter (OM) in Soil fertility

1. Soil is the most important natural resources and its fertility and quality indicator for sustainable crop production.
2. OM is the vital factor for retaining nutrient in soil. It also resource of plant nutrient especially N and some micro nutrient.
3. OM improves soil structures through aggregation that favourably influence tillage free operative crusting, water infiltration, moisture retaintion, aeration, temperature and root penetration.
4. OM influence water holding capacity of soil, reduce residual negative effect of fertilizers and pesticides.
5. It makes the crop more tolerant to disease, insects and also prevent soil erosion.
6. OM increases the capacity of soil to buffer and phosphates fixation.
7. OM is the energy for soil microorganism which are the primary agent that enhanced the decomposition and release of mineral in soil.
8. It prevents leaching loss of different nutrients.
9. It makes phosphorus more available in acid soil and reduces alkalinity in the soil.
10. OM also create a positive soil environment from which plant can uptake nutrient from applied chemical fertilizer.
11. It increases uptake of chemical fertilizers by plants thereby increases crop productivity and reduces toxic flow of active chemical fertilizer to the environment. Thus the optimum level of OM builds and maintain positive soil properties that support plant growth.

Causes of Soil Depletion

The main causes of soil depletion are the accumulation of pathogenic microorganisms (fungi, bacteria, viruses) that inhibit the growth of certain plants by their secretions or by infesting the

roots; the development of pests and weeds; and soil exhaustion. some other causes are given below-

- 1. Loss of top soil by erosion:** This is the removal of the topmost soil by either water or wind. When the topmost soil is taken away, it exposes the layer beneath for further loss, as nutrients are taken away as the topmost soil is removed.
- 2. Nutrient Leaching:** It is the leaching of nutrients deep down the soil by water draining down the soil. This leads to displacement of nutrients beyond the reach of roots of plants.
- 3. Continuous cropping:** It is the continuous cultivation of crops on the same piece of land without allowing the land to fallow. This over exploitation and excessive use of nutrients in the soil leads to their depletion eventually.
- 4. Compacting:** Soil compacting is as a result of the impact of humans, animals and machines on a piece of land long enough to disturb the soil structure. Over long periods, essential components of the soil are lost such as soil air, microorganisms and certain plants that may offer some protection. This is mainly through walking and use of land for certain human activities, impact from cars and machinery as they apply direct force to the soil.
- 5. Flooding and excessive irrigation:** This leads to excessive water present on land. Excess water drains away nutrients from the soil rendering it deficient.
- 6. Crop removal:** some crops offer some form of protection for soil against soil erosion and evaporation which might otherwise lead to loss of soil nutrients and water.
- 7. Decrease in organic matter content and soil bioactivity:** The decreased levels of organic matter causes a strong reduction in soil fertility as it plays several roles in soil. The microbial activities in soil decrease due to reduced levels of organic matter. These microbial activities play significant role in nutrient availability and recycling. Decreased organic matter levels results in poor physical, chemical and biological properties.
- 8. Soil acidification, salinization and alkalinization:** Acidification, salinization or alkalinization causes reduction in soil fertility, and eventually lead to problems of nutrient deficiencies, toxicities and imbalances. Factors responsible for soil degradation are generally interrelated.
- 9. Inefficient soil management:** Poor or inefficient soil management results in decreased soil fertility. Improper crop rotations followed may decrease the soil fertility tremendously. Excessive soil tillage leads to erosion of the soil which leads to reduced soil fertility.
- 10. Soil pollution:** Soil pollution caused by indiscriminate use of agro-chemicals and heavy metals reduces fertility of soil by affecting the soil biological properties. The growth of useful soil organisms is adversely affected which eventually causes a decline in biological soil fertility.

C:N Ratio

It is the intimate relationship between organic matter and nitrogen contents of soil. The ratio of the weight of organic carbon to the weight of total Nitrogen in a soil or organic material is known as C:N ratio.

Or,

It is defined as the ratio of the weight of organic carbon to the weight of total nitrogen in soil or organic material. The ratio of C:N in normal aerobic soil usually varies 10 or 12:1.

Or,

C:N ratio is a ratio of the mass of carbon to the mass of N in a substance, C:N ratio are an indicator for nitrogen limitation of plants and other organism.

Significance of C:N ratio

When Organic matter or fresh plant residues of high C:N are added to soil, it is gradually degraded or decomposed by microorganism and C is lost as CO₂. As a result the C:N of the material is reduced and finally attain a more or less stable C:N of 10:1. At this stage, Organic matter is added and converted to humus. C:N plays an important role in the decomposition of OM in the following ways-

1. Keen competition for available N: When organic residues with a wide C:N ratio (50:1) are incorporated in the soil, a keen competition occur between the microorganism and plants for mineral N presence in soil. High C content of organic matter causes rapid growth of microbes resulting in a disappearance of Nitrate-nitrogen from the soil because of the instant microbial demand for this element. And for the time being little or not N is available to plants. Consequently plant growth is affected as the decompose proceed, the C:N of the organic matter decreases since C is being lost as CO₂ and N is conserved. N becomes again available to plants through mineralization of N take microbial cells.

2. Consistency of C:N: As the decomposition process continue both C and N are now subjected to loss, the C as CO₂ and N as NO₃ which are leached or adsorbed by plants. At a point, C:N becomes more or less constant, generally stabilised at 10:1 or 12:1.

It has always been consider profitable to mix the highly carboneous material like straw with a small quantity of ammonium sulphate. With this available sources of N from ammonium sulphate, the decomposition of fresh organic matter is hastened and thus the release of available N is affected in a shorter period of time. The maintenance of carbon and hence soil organic matter depends largely on the soil N-level.

3. This ratio is an important factor determining how easily bacteria are able to decompose an organic material.

4. The microorganisms in compost use carbon for energy and nitrogen for protein synthesis,

just as we use carbohydrates for energy and protein to build and repair our bodies.

5. The optimal proportion of these two elements used by the bacteria averages about 30 parts carbon to 1 part nitrogen.

6. Given a steady diet at this 30:1 ratio, they can decompose organic materials very quickly.

Organic matter Decomposition

The organic materials (plant and animal residues) incorporated in the soil are attacked by a variety of microbes, worms and insects in the soil if the soil is moist. Some of the constituents are decomposed very rapidly, some less readily and others very slowly.

▲ The list of constituents in terms of ease of decomposition-

1. Sugars, starches and simple proteins → Rapid Decomposition
2. Crude proteins.
3. Hemicelluloses.
4. Cellulose.
5. Fats, waxes, resins.
6. Lignins → Very slow Decomposition.

▲ The organic matter is also classified on the basis of their rate of decomposition-

1. **Rapidly decomposed:** Sugars, starches, proteins etc.
2. **Less rapidly decomposed:** Hemicelluloses, celluloses etc.
3. **Very slowly decomposed:** Fats, waxes, resins, lignins etc.
4. **Simple decomposition products,** Aerobic – CO_2 , H_2O , NO_3 , SO_4 .

▲ When organic material is added to soil, three general reactions take place-

- a. The bulk of the material undergoes enzymatic oxidation with CO_2 , water, energy and heat as the major products.
- b. The essential elements such as N, P and S are released and or immobilized by a series of reactions.

Compounds very resistant to microbial action is formed either through modification of compounds or by microbial synthesis.

(A) Decomposition of Soluble Substances

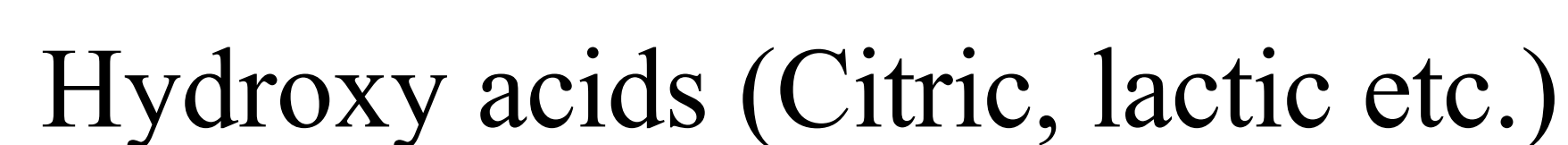
Sugar and water-soluble nitrogenous compounds are the first to be decomposed as they offer a very readily available source of carbon, nitrogen and energy for the microorganisms. Thus, when glucose is decomposed under aerobic conditions, the reaction is as under:



Under partially oxidized conditions,



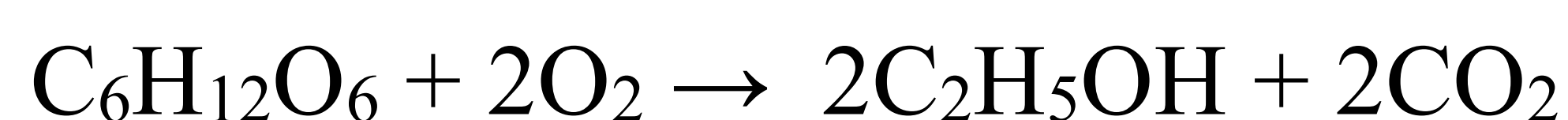
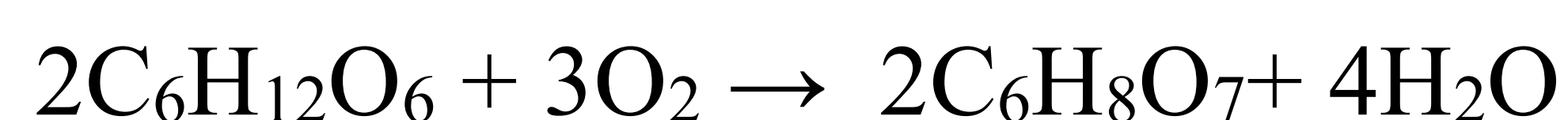
or



or



Some of the reactions invoiced may be represented as under:



(i) Ammonification

Soluble nitrogenous compounds like amino acids, amides, ammonium compounds, nitrates etc., are also attacked by the microorganisms. The transformation of organic nitrogenous compounds into ammonia is called ammonification. During the course of action under aerobic conditions by heterotrophic organisms, oxygen is taken up and carbon dioxide is released. Ammonification process involves a gradual simplification of complex compounds.



Or



The ammonification occurs as a result of action of enzymes produced by microorganisms. Their action is chiefly hydrolytic and oxidative (in the presence of air).

(ii) Nitrification

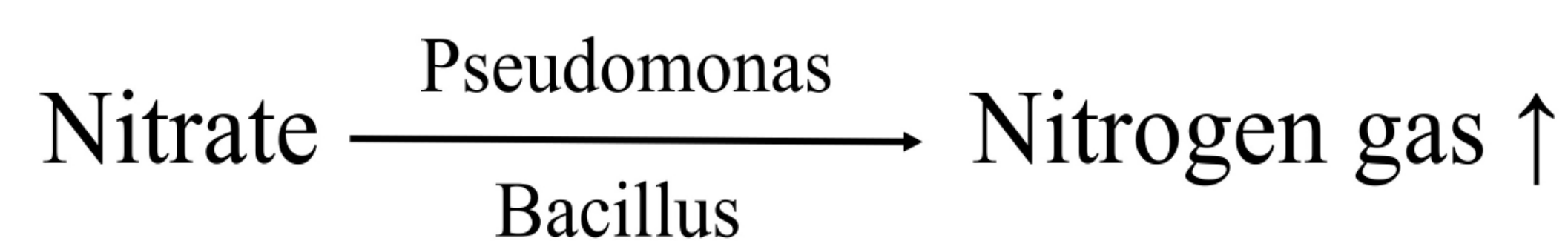
The process of conversion of ammonia to nitrite (NO_2) and then to nitrate (NO_3) is known as nitrification. The production of nitrate is more rapid than that of nitrite, while the formation of ammonia is the slowest process. That is why soil usually contains more nitrate nitrogen than nitrite at any time. Nitrification is an aerobic process involving the production of nitrates from

ammonium salts.



(iii) Denitrification

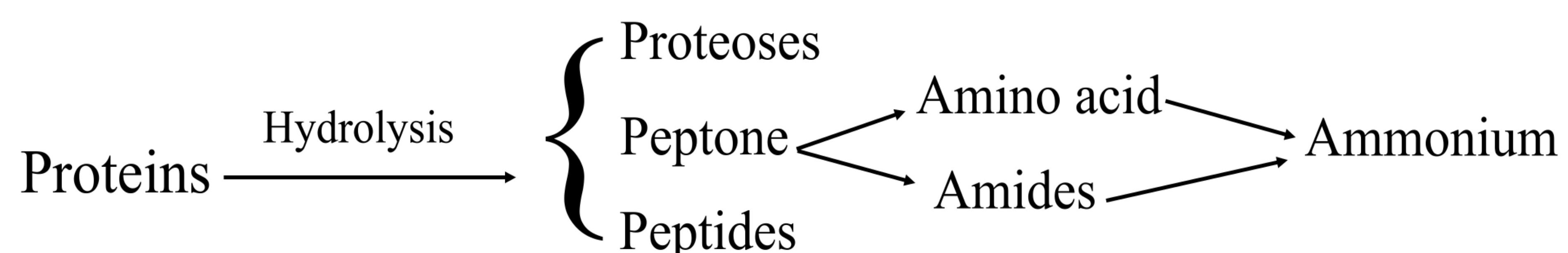
The process, which involves conversion of soil nitrate into gaseous nitrogen or nitrous oxide, is called Denitrification. Water logging and high pH will increase N loss by Denitrification.



Water-logging (e.g., Rice field) and high pH will increase nitrogen loss by de-nitrification.

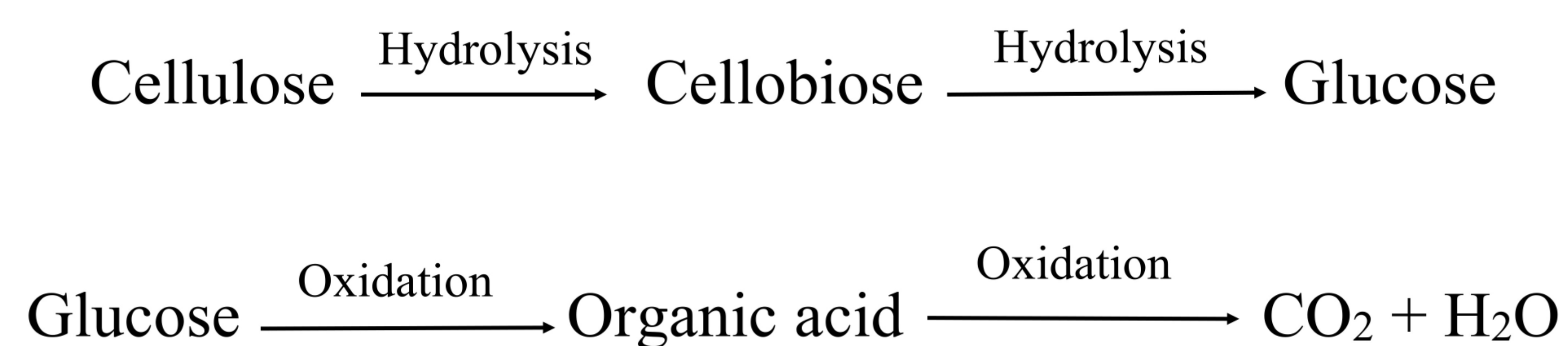
(B) Decomposition of Insoluble Substances

1. Breakdown of Protein: Proteins are complex organic substances containing nitrogen, sulphur, and sometimes phosphorus, in addition to carbon, hydrogen and oxygen. During the course of decomposition of plant materials, the proteins are first hydrolysed to a number of intermediate products, e.g., proteoses, peptones, peptides, etc., collectively known as polypeptides. The changes may be represented as under:



The process of conversion of proteins to amino acids is known as aminization.

(2) Breakdown of Cellulose: Cellulose is the most abundant carbohydrate present in plant residues. The microorganisms break up cellulose into cellobiose and glucose. Glucose is further attacked by organisms and converted into organic acids:



The decomposition of cellulose in acid soils proceeds more slowly than in neutral and alkaline soils. It is quite rapid in well-aerated soils and comparatively slow in those poorly-aerated.

(3) Breakdown of Hemicellulose: When subjected to microbial decomposition, hemicelluloses are first hydrolysed to their component sugars and uronic acids. The sugars are further attacked by microorganisms. They are converted to organic acids, alcohols, carbon dioxide and water. The uronic acids are broken down to pentose and carbon dioxide. The newly synthesised Hemicelluloses thus form a part of the humus. Hemicelluloses decompose

faster than cellulose.

(4) Breakdown of Starch: Chemically it is glucose polymer. It is first hydrolysed to maltose by the action of enzymes (amylases). Maltose is next converted to glucose by another enzymes (maltase). Glucose being soluble in water is utilized for growth and other metabolic activities.

(C) Decomposition of Ether-soluble substances

Fats are first broken down by microorganisms through the agency of enzyme lipase into glycerol and fatty acids. Glycerol is next oxidised to organic acids which along with the other fatty acids are finally oxidised to carbon dioxide and water.

(D) Decomposition of Lignin

Lignin is deposited on the cell wall to impart strength to the framework of plant. Lignin decomposes slowly, much slower than cellulose. Complete oxidation of lignin gives rise to carbon dioxide and water.

(E) Simple Decomposition Products

As the enzymic changes of the soil organic matter proceed, simple products begin to manifest themselves. Some of these especially carbon dioxide and water, appear immediately. Others such as nitrate nitrogen, accumulate only after the peak of the vigorous decomposition is over. The more common simple products resulting from the activity of the soil microorganisms are as follows:

Carbon: CO_2 , CO_3^{2-} , HCO_3^- , CH_4 , C

Nitrogen: NH_4^+ , NO_2^- , NO_3^- , N_2 (gas)

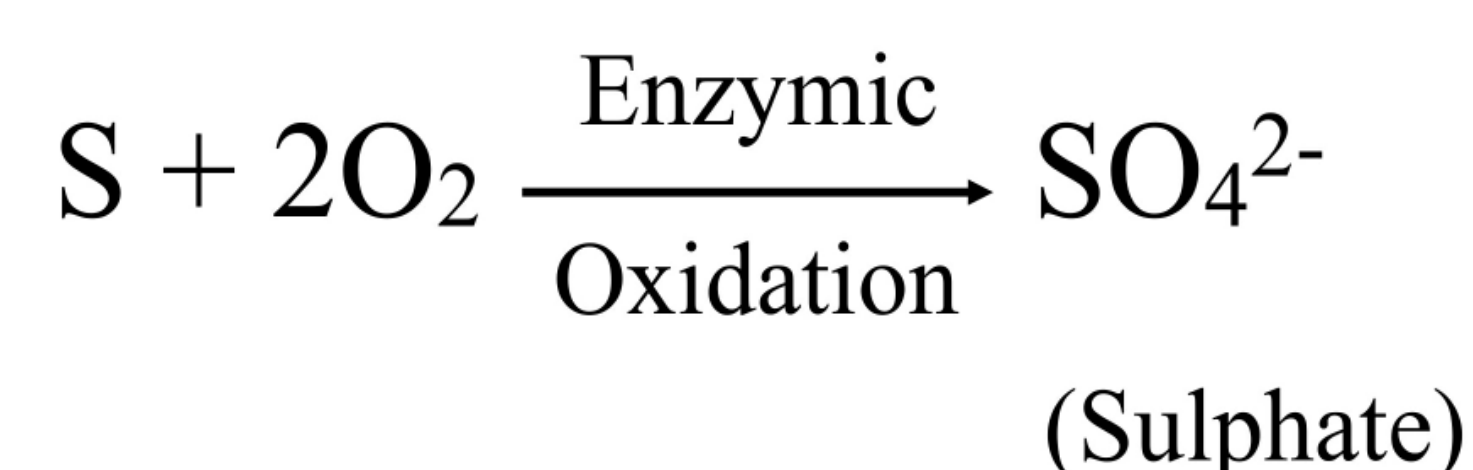
Sulfur: S, H_2S , SO_3^{2-} , SO_4^{2-} , CS_2

Phosphorus: H_2PO_4^- , HPO_4^{2-}

Others: H_2O , O_2 , H_2 , H^+ , OH^- , K^+ , Ca^{2+} , Mg^{2+} etc.

(F) Mineralization of Organic Sulphur

Many organic compounds especially those of nitrogenous nature, carry sulphur. Heterotrophic bacteria simplify the complex organic compounds, then autotrophic bacteria (sulphur bacteria) oxidize it into sulphate form.



(G) Mineralization of Organic Phosphorus

A large proportion of the soil phosphorus is carried in organic combinations. Upon attack by microorganisms the organic phosphorus compounds are mineralized; that is, they are changed

to inorganic combinations. It depends upon soil pH. As the pH goes up from 5.5 to 7.5 the available phosphorus changes from H_2PO_4^- to HPO_4^{2-} . Both of these forms are available to higher plants.

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